

1972, p. 107. The authors of the present investigation have also observed the formation of a similar structure in the laboratory. The following description is based on the work of J. M. Boudry, J. M. Martin, and J. P. Gaudin, J. Marine Biol. Ass. U.K., 1972, p. 107. The authors of the present investigation have also observed the formation of a similar structure in the laboratory. The following description is based on the work of J. M. Boudry, J. M. Martin, and J. P. Gaudin, J. Marine Biol. Ass. U.K., 1972, p. 107.

1702 Distributions and water masses
1960-1961, OBSERVATION OF THE COASTS OF CALIFORNIA
JULY 1962

1. Paul Foulger, NOAA Pacific Marine Environment
Laboratory, 10100 NE 4th Avenue, Seattle,
Washington 98105; and D. Hufnagel
A hydrographic survey of the 38° 47'N station was
conducted on 10-11-62. The station is located
(38° 47'N, near San Francisco) and 35° 15'N, Cape
Pinto in southern Oregon. Coastal upwelling was
observed at the Cape Mendocino station at 39° 01'N
on an intense temperature front. The frontal zone
occurred between 38° and 39°. The dynamic height
exceeded 1000 db and 30/700 db remained
constant. The 1000 db surface was 100-150 m
deep. The 1000 db of Cape Mendocino the same
saline water identified as the poleward California
Current. The 1000 db surface was 100-150 m
deep. Integrated above 500 db was southward,
California Current and Uncurrent, eddies,
J. C. Gentry, B. J. Green, Nov. 1962

27235 *Estuaries, bays, and floods*
SALINITY-DEPENDENT MEASUREMENT OF TIDALLY
INDUCED SALINITY GRADIENTS OFF THE GEORGIA COAST
AND IN THE SAVANNAH RIVER, CHESAPEAKE BAY, AND
HAMPSON, VA 23855 and J. Mearns
A quasi-synoptic survey of tidally induced
salinity gradients in the lower Chesapeake Bay was
performed using a L-shaped mobile radiometer aboard
a NSA aircraft. Salinity maps were obtained for
the entire Chesapeake Bay and used to define the
salinity distributions near rivers and sounds and
major changes that occur from bay flow to flood
conditions. Salinity gradients were defined as the
salinity regime and extended over from the Savannah
River mouth about 12 km during ebb tidal condi-
tions. Salinity gradients were defined as the
salinity water extending along the Georgia-South
Carolina coast which was produced by the many
estuaries and sounds along the coast of the
vicinity. The changes in salinity observed off-
shore of the river plume area were consistent
with the salinity gradient in the estuary and
the typical tidal excursion perpendicular to the
on-shore gradient. Salinity, tide, coastal

1985 Surface waves, tides, and sea level
 TIDE AND SEA LEVEL POTENTIAL VS. STIDES
 WAVE PREDICATION
 K. F. Lambros (Exxon Production Research
 Company, Houston, Texas)
 The velocity potential for finite surface
 water waves is expressed in terms of a double
 Fourier series expansion in the wave number and
 frequency. The nature of the velocity potential
 permits nonlinear interactions between waves
 and harmonics and can describe periodic waves as well
 as wave packets. The results are presented in the
 Stogatz type views. The uniformity of the
 EAP wave is that part of the energy in each
 harmonic component is transferred from the
 primary wave to the higher order harmonics.
 The outward effect of the nonlinear interac-
 tions is the modulation and demodulation of the
 wave packet. The changes in wave
 shape affect the wave linearization. The
 results are presented to illustrate this
 effect. Also, in the hands of examples the EAP
 solution, on the basis of the Stogatz type
 accuracy to the wave number N solution
 but in close agreement with other higher order
 solutions.
 J. G. Lambros, Exxon Production Research Company

A general expression is derived for the horizontal particle velocities in Lag waves. The theoretical results are compared with the experimental data of A. Freden (Inst. Hydrodyn. and Hydraulic Eng., Tech. Univ. Denmark, Building 115, Copenhagen, Denmark) for waves of height 10 cm. The vertical coordinate z which results in an increase for z in the sense of the surface elevation of the wave is found to be the same for waves of high but not for waves of low height. The results for waves of high but not for waves of low height are in good agreement with the results obtained from the wave theory. The results for waves of low height are in good agreement with the results obtained from the wave theory. The results for waves of low height are in good agreement with the results obtained from the wave theory.

4790 Instruments and techniques
OBSERVATIONS OF WATER FLUX WITH HIGH RESOLUTION
DOPPLER SCARF
R. D. HODGSON (University of Miami, Rosenstiel
School of Marine and Atmospheric Science, 4600
Rickenbacker Causeway, Miami, Florida 33149)
The use of a Doppler Scarf with a few cen-
timeter range resolution provides a means for
monitoring of slow water velocity with excellent
accuracy. The appropriate parameters in the
paper were conducted with the use of a transducer
resting on the floor of a waterway influenced
by the water surface with the transducer producing
a sine filled wave. The water surface transducer
waves are shown in the form of bipolar Scarf
composed of radial velocity estimates separated
into two groups which are plotted as a function
of range span spaced by 4.5 or 9 cm, as the
vertical profile of horizontal velocity extends
from the water surface to the water near-
bottom. The Scarf is used to determine the
face in derived from the data. The Scarf
plotting of these profiles shows considerable de-
tails of the fluctuation of the ship/floor charac-
teristics of the water surface (water flow).
(Support from NSF, Grant OCE 78-10081)

4790 Instruments and techniques
NEARST X-BAND CROSS-SECTION MODULATION BY SURFACE
WINDS; ROSSER OBSERVATIONS
R. Thompson (University Science Institute,
Science Applications, 3500 Pasadena, CA 91101)
D.E. Neilman, and V.I. Gostalar
Satellite radar observations of the Gulf of Alia
off the coast of Saudi Arabia (25-30°N, 35-40°E)
using the SeaWinds scatterometer (SAS) indicate that
wind speed backscatter is modulated by wind speed
and by wind direction. In particular, 1-
band radar backscatter is modulated by wind speed
angle of incidence is related to wind speed and
direction by the following:
$$\sigma_{\text{back}} = a + b \cos \theta \quad (4)$$

where θ is L-band radar angle of incidence, a is
wind speed, and b is wind-radar angle, a is 0.3 +
0.1, and b is 0.05 + 0.05. This relationship
allows for the determination of SeaWiFS and
SeaWiFS scatterometer data may yield the resolution
of surface winds.

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

This paper is the last of three parts. The previous two parts were published in Eos January 13 and February 3.

The simple models of shelf circulation components discussed so far were based on the coastal constraint assumption and longshore uniformity. This is clearly restrictive: how far from shore the coastal constraint is valid is itself one of the important questions in shelf dynamics. A longshore sea-level gradient constant in space and time is evidently not a realistic assumption over larger pieces of the coastline. The focus of much recent work on shelf dynamics has been on determining the mechanism that allows longshore sea-level gradients to exist along open shelves, and the distribution of such gradients. The excitement of finding answers to such questions is still fresh for those of us involved in the exercise. In a simple approach, it is reasonable to neglect the small-scale variations of shelf topography or of forcing in the longshore direction and to focus on such physical influences as might changes in coastline orientation or wind stress variations on the scale of weather systems. It is then still realistic to regard the coastal zone of interest as a narrow boundary region of a larger-scale circulation pattern. An appropriately simplified equation governing coastal sea levels now takes on the form of the heat conduction (or diffusion) equation, according to which any sea-level perturbation spreads out in the offshore direction, proceeding in a cycloidal direction alongshore. The theoretical model thus predicts the formation of an inner-shelf boundary layer which thickens in one specific longshore direction only, and that is in the direction of long-wave propagation.

The rate at which the frictional coastal boundary layer grows (related to the effective horizontal diffusivity for sea-level perturbations) is proportional to the bottom resistance coefficient. In typical cases, a disturbance comes to occupy the entire shelf width (order 100 km) in a longshore distance of order 2000 km, (which is comparable to the scale of weather systems or to continental dimensions. Much closer to the source of the disturbance (which may be simply a change of coast orientation), its effects remain confined to an inner-shelf boundary layer.

The boundary layer model allows considerable insight into the mechanism of longshore pressure gradient generation by such local influences on a shelf region as longshore or cross-shore wind stress distributed in an arbitrary way. Figures 1

TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
The Weekly Newspaper of Geophysics

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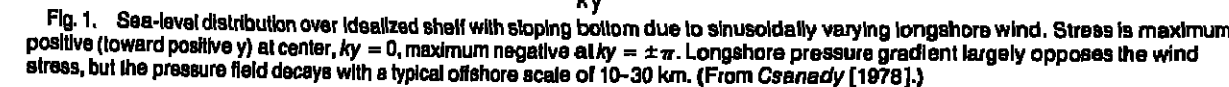
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Cover. This photo presents an interesting meteorological question. These cloud patterns, imaged from space by a Defense Meteorological Satellite, were produced by a mature mid-latitude cyclone with a well-developed typhoon-like rotated near the southern edge of the occluded front. The thermal infrared band image, in which the brightest areas are higher (colder) cloud tops and the gray areas are lower clouds, was taken over the eastern Pacific Ocean about 2500 km off the California coast, in 1975. This image is oriented north (top)-south (bottom), with the nearest northwest land masses being the Aleutian Islands. The southernmost portion of the image is near the equator. (Photograph and information courtesy of James Barnes and Alan Buffey, Environmental Research & Technology, Inc., Concord, Mass.)



and 2 illustrate the effect of a sinusoidally varying longshore wind on a long, straight shelf of constant slope, with the deep ocean supposed "inert." The first of these illustrations shows that a varying longshore wind sets up a coastally trapped steady pressure field akin to a topographic wave. If the longshore wavelength of the forcing is 1000 km, a typical value of the bottom resistance coefficient results in a trapping width of 50 km, i.e., trapping in a moderately narrow nearshore band. The dynamical role of the peculiar pressure field is elucidated somewhat by the transport streamline pattern of Figure 2. This figure shows the transition between the region where the coastal constraint is valid, and the longshore force balance is between wind stress, bottom stress, and longshore pressure gradient, and an "outer-shelf" region where the total transport is only what flows onshore or offshore in a surface Ekman layer, so that most of the water column is recirculating.

Figure 1 shows that a specific distribution of surface levels is required to bring about the required balance of forces and that this is associated with a peculiar distribution of interior velocities over the inner shelf. Certainly physical intuition would not lead one to expect such a distribution. Of particular practical importance is the model prediction that the cross-shore transport can be of significant magnitude as close to shore as 10 km, depending on topography, forcing, etc. The inner-shelf longshore current transports varying amounts of fluid, accepting the inflow from a surface Ekman layer further offshore, where the longshore wind stress drives it shoreward, and supplying the outflow, where the longshore stress is oppositely directed.

In a qualitative application of this model to realistic coastline geometry, one may think of longshore variations in forcing as being due to changes of coastline orientation. The calculated results suggest that the flow accommodates itself to such changes within an inner-shell boundary layer, with the outer shelf not being affected. The open circulation cells associated with the flow adjustment should have considerable practical importance as a mass exchange mechanism.

More complex wind fields lead to more complex solutions. Whatever the details, however, the parabolic nature of the governing equation and the effective horizontal diffusivity related to bottom friction govern the character of the solutions. Different driving forces may be thought of as driving different components of shelf circulation that are simply additive.

The effects of variable cross-shore wind stress show some interesting effects not revealed by the previous illustrations (Figures 3 and 4). The sea-level distribution is characterized by something like wind setup, showing a drop in levels near the maximum offshore wind and a rise near the onshore wind maximum. However, surface-level gradients are only significant within a coastally trapped band, which should have a typical width in practice of 10–30 km. Outside this band, the cross-shore wind stress is balanced by Ekman drift, as in the deep ocean. However, the Ekman drift in this case is not constant but rather has convergent and divergent regions. Over a sloping shelf, this leads to massive onshore flow (outside the region where setup is important) where the surface layer is divergent, offshore flow where it is convergent.

A potentially important forcing effect on the shelf circulation is the pressure field impressed by the deep ocean. In the boundary layer model, this appears as a boundary condition at the outer edge. A longshore pressure gradient impressed at the edge of the shelf affects the entire shelf much as the free-stream pressure gradient affects a laboratory boundary layer, on the reasonable supposition that the longshore scale of such a gradient is comparable to oceanic dimensions. Such an 'impressed' pressure gradient is thus more or less constant with distance from shore and leads to effects as discussed in the connection with the parallel flow shelf circulation.



lation model (Figure 6, part 2: Eos, February 3)

The effects of variable freshwater inflow are also easily treated with the aid of the boundary layer model. Freshwater inflow is concentrated in major rivers, and even if each of these becomes effectively distributed over a few hundred miles of coastline, there are important variations in the rate of inflow between, say, the northerly and southerly part of continents. Such variations are responsible for longshore density and, hence, pressure gradients, which may be significant producers of shelf circulation. For example, if the density changes by 1 part in 1000 over a longshore distance of 1000 km, over a water column 100 m deep, a longshore sea-level slope of 10^{-7} results (1 cm in 100 km), which is of the same order as longshore gradients that are due to other causes. A slope of this magnitude should drive massive longshore flow, according to the boundary layer model.

Over the Mid-Atlantic Bight, the observational evidence suggests that no significant trapped cells affect the mean flow beyond the 30-m isobath or so. The key driving force, the longshore pressure gradient, is then very likely a deepwater effect, impressed upon the shelf by offshore oceanic gyres. At the edge of the shelf this longshore gradient is certainly as large as it is closer to shore.

The magnitude of the longshore pressure gradient is not constant in time, however, but is subject to clear seasonal—and perhaps longer-term—variation. An interesting aside is that at the time of the *Argo Merchant* oil spill off Nantucket Island (December 1976), the usual southwestward driving longshore pressure gradient was fortuitously absent, and the water column was moving eastward under strong northwest winds, taking the oil spill eastward and out to sea.

One factor contributing to longshore sea-level gradient, at least in the northern portion of the Mid-Atlantic Bight, appears to be freshwater influx further north, notably in the Gulf of Maine and the Gulf of St. Lawrence. According to the boundary layer model, longshore variations of freshwater influx over such a long range (order 1000 km) affect more or less the entire width of the shelf, which would make their effects difficult to distinguish from deepwater gyre effects. The magnitude of the longshore pressure gradient that is due to observed density variations may be estimated to be 1 cm in 100 km (10^{-7}) during the spring runoff period only, and a much lower slope at other times of the year. This effect may partly explain the seasonal variation of the longshore gradient.

Explanations for the observed variations in the long-term gradient are based on the inner core evidence for the long-term trapped cells affecting the long-term mean circulation pattern as deduced from nearshore studies in different locations. These show different magnitudes of the longshore pressure gradient. Near the 'apex' of New York Bight, such local variations are particularly clear. The details of these trapped cells have not been elucidated so far, at least not in connection with a long-term mean circulation pattern. On the other hand, there is clear evidence which shows that trapped pressure fields accompany storms.

Storm Currents over Atlantic-Type Shelves

From an economical point of view, the most important problem in applied oceanography is the prediction of storm surges, which from time to time cause tremendous damages along coastlines adjacent to broad continental shelves such as the North Sea, the U.S. Gulf Coast, and the East Coast. Consequently, numerical models are well developed for the prediction of coastal sea levels associated with hurricanes and extratropical storms. These models have been calibrated empirically and today constitute a useful practical tool. They do not, however, give a particularly realistic description of storm-driven currents, at least not without considerable further

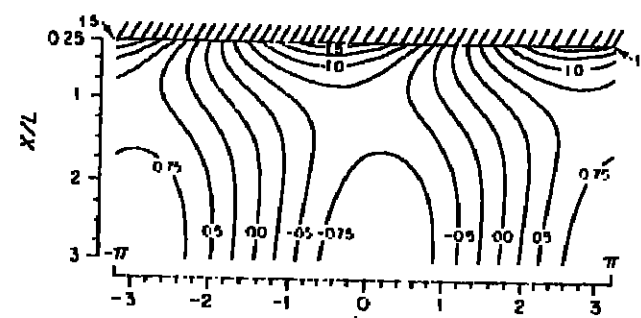


Fig. 3. Sea-level distribution over idealized sloping shelf due to sinusoidally variable cross-shore wind stress. Wind stress is maximum offshore at $ky = 0$, maximum onshore at $ky = \pi$. Setup opposes the wind over the inner shelf, while over outer shelf, sea-level distribution is in geostrophic balance with subsurface flow (see next illustration). (From Csanady [1980].)

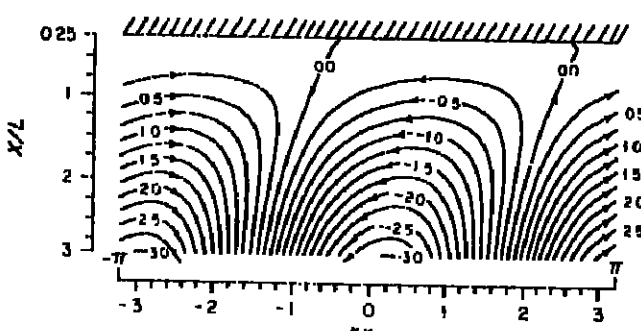


Fig. 4. Transport streamlines corresponding to pressure field in Figure 3. Over outer shelf there is massive onshore flow in region where wind stress curl is cyclonic ($ky < \pi/2$), offshore flow where anticyclonic ($ky > \pi/2$).

development and calibration. In any event, the predictions of the models are almost as complex as the observational evidence, and it is desirable to understand the contribution of storms to the circulation problem in terms of simpler concepts.

Strong winds acting over shallow water rapidly establish frictional equilibrium flow, so that this aspect of the circulation problem is best approached by way of steady state models. The classical models of hurricane surge are of this kind [Freeman *et al.*, 1957; Bretschneider, 1966]. Although wave-like 'resurgences' are sometimes important, the bulk of the coastal sea level rise attributable to storms can be explained as a steady state, coastally trapped pressure field. Associated with this pressure field are intense longshore currents which are generated by storms, presumably giving rise to large particle displacements. Bolcourt and Hacker [1976] point out, for example, that most of the mean southwestward drift off Chesapeake Bay in the Mid-Atlantic Bight is generated by a few northeasterlies, as vividly illustrated in their paper through the use of progressive vector diagrams of observed currents.

In a steady state model, coastal sea level rise is due to two effects: setup in response to onshore wind and geostrophic adjustment to balance the Coriolis force of longshore currents. From the point of view of the circulation problem, coastal sea levels are incidental, but of course longshore gradients of sea level that form part of a trapped pressure field under a storm affect the intensity of longshore currents. Of great practical importance for mass exchange are the cross-shore motions in the open circulation cells associated with trapped pressure fields. The simple boundary layer models discussed above have shown that the longshore scale (wavelength) of the forcing by wind is of key importance in determining the circulation pattern. Storms of small spatial scale may create a particularly intense circulation cell on the continental shelf.

Extratropical storms have typical scales of 1000 km and more. Hurricanes are 3–10 times smaller in diameter, but their maximum winds are much higher. Maximum wind stress in a hurricane reaches values of 30 Pa and more.

Clear evidence for a trapped pressure field associated with hurricanes has already been presented by Redfield and Miller [1957] (see Figure 5 here). The maximum longshore sea-level gradient shown in this illustration is about 8×10^{-6} , which, in water 50 m deep, would alone drive a longshore current with a velocity of about 1.5 m/s. Moreover, this gradient drives the water in the same direction as the longshore stress ahead of the eye of the hurricane just prior to landfall and so increases the maximum longshore current above what the wind stress alone would produce.

Intuitively, the sea-level distribution shown in Figure 5 is not difficult to understand as an effect of the cross-shore

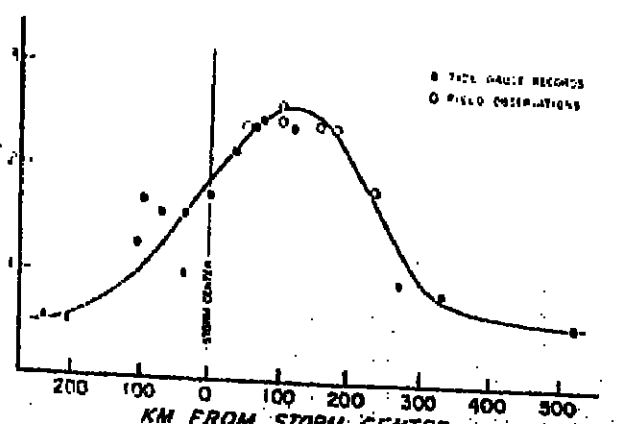


Fig. 5. Sea-surface elevations accompanying Atlantic coast hurricanes, from Redfield and Miller [1957]. Maximum elevation occurs well to the right of the storm center, looking along the path of the storm as it crosses onto land.

component of the wind that causes a setup to one side of the eye, a set-down to the other side. A similar effect is revealed by the boundary-layer shelf model acted upon by variable cross-shore wind, the sea-level distribution for which is shown in Figure 3. Figure 4 shows the corresponding stream-line pattern. The equivalent of the eye of a storm is located in both figures to the right of the center, where the cyclonic curl of the wind stress causes substantial onshore transport. The coastally trapped pressure field is instrumental in deflecting the onshore flow in a longshore direction and causes strong longshore currents without any longshore wind. In an actual storm, of course, the important effects of longshore winds are superimposed on this pattern.

The longshore component of the wind in a storm generates a pressure field that generally opposes the wind stress, and hence the longshore current close to the coast (cf. Figure 1). Summing the effects of cross-shore and longshore winds causes partial cancellation of the longshore gradient in the case when the storm center is located offshore. With the storm center over land, the pressure gradients add up, both opposing the direct driving force of the wind. The relative strength of the longshore gradients produced depends on the spatial extent of the storm. For a hurricane (small diameter), the cross-shore wind effect dominates, as empirical data show in Figure 5 above. The longshore elevation gradient that is due to longshore wind is relatively more important for an extratropical storm of large diameter.

In the Mid-Atlantic Bight, extratropical storms that have their centers well to the south of the Bight produce vigorous southwestward flow, while storms with their centers well to the north, although they apply intense local wind stress directed to the northeast, produce little net flow because their effect is balanced mainly by an opposing sea-level gradient. The phenomenon may be explained if one supposes that in such larger storms the cross-shore and the longshore wind effects are roughly equal as far as longshore pressure gradient generation is concerned. With the storm center offshore, nearly complete cancellation may then be expected, while a particularly strong gradient should oppose the longshore wind stress when the storm center is well to the north.

Mean Circulation of a Stratified Fluid

In discussing the development of wind-driven transient flow in a stratified fluid, it was noted that the isopycnals rise or sink in a relatively narrow nearshore band that is scaled by the internal radius of deformation, and they undergo large vertical excursions, even under modest wind stress impulses. If a steady state flow pattern is eventually approached in such a case, the tendency to vertical isopycnal displacement within the same nearshore band should persist and must be counteracted by dissipative processes, mixing, and internal friction. A steady state pattern of upwelling or downwelling circulation then comes into existence in which the vertical advection of temperature and salinity is balanced by mixing across (and along) isopycnals. Modeling of the flow and pressure fields associated with similar phenomena is greatly hampered by our limited understanding of dissipative processes in a stratified fluid. In a recent review article, Allen [1980] concludes that similar model studies are all more or less unrealistic for this reason. At the same time, however, these model studies clearly show that a boundary layer of a scale of the internal radius of deformation may well accomplish mass balance closure in somewhat the same way as the frictional boundary layer over a slope (Figure 2 or 4), i.e., accepting Ekman transport over some portions of the coast and supplying it over other portions.

Given the absence of a realistic parameterization scheme for nearshore dissipative processes in a stratified fluid, the simplest step is to ignore them and construct a steady circulation model without friction and mixing. In the absence of mixing and friction, the fluid conserves potential vorticity, and a flow pattern may be calculated without difficulty by using linearized theory. This pattern is illustrated in Figure 6.

In this illustration, the total transport equals the Ekman drift over most of the basin, so that below the Ekman layer the fluid is quiescent. A coastal boundary layer, typically 5–10 km wide, accepts the Ekman drift along the right-hand shore and transports it around the ends of the basin to the coastal boundary layer along the left-hand shore, which supplies the fluid for the interior Ekman transport. The surface remains flat, except within the coastal boundary layers. Along the shores parallel to the wind, a pressure gradient opposes the wind in the upper layer, but the lower layer is entirely quiescent. Correspondingly, the pycnocline has a strong tilt in the longshore direction as well as cross-shore. At the coast, there is exact balance between wind stress and pressure gradient force in the upper layers.

One should not take too seriously the details of this simple linear theory flow pattern. The main point is that the adjustment of the isopycnals to a steady flow pattern may allow a transition from a quiescent interior (except for surface Ekman drift) to an active coastal boundary layer over a distance range of 5–10 km. In particular, a longshore pycnocline tilt may develop, generating a pressure gradient in opposition to the wind in the top layer alone and confined to a coastal band. Dissipative processes would presumably spread out the trapped density field implied by this model to a scale larger than the internal radius of deformation, but the basic character of the pycnocline tilts might well remain as predicted by the model. Along continental slopes, in particular, a considerable range of depth is available for the development of longshore isopycnal tilt.

The monthly average summer circulation in Lake Ontario is sometimes found to exhibit a coastal jet pattern similar to that shown in Figure 6, at least along the south shore. The analysis of IFVGL (International Field Year on the Great Lakes) data for July and August showed that along this shore eastward and westward jets in warm water were associated with a thermocline tilt both cross-shore, for geostrophic equilibrium, and longshore. The longshore thermocline tilt corre-

Fig. 6. Steady transport streamline pattern in two-layer fluid contained in a 5:1 rectangular container acted upon by steady wind. Surface-level distribution is flat in the center but is characterized by strong gradients in a coastal boundary layer (scale width, the internal radius of deformation) both cross-shore, for geostrophic balance, and longshore, opposing the wind. (From Csanady and Scott [1974].)

sponded to a pressure gradient not quite sufficient to balance the wind stress. The north shore pattern was, however, drastically different, and there were also other complexities which, for the present, remain unexplained. Part of the difficulty is probably that long-term fixed-point mean currents do not reflect particle velocities and are physically more or less meaningless.

Many observations of currents, densities, etc., are available during the summer (upwelling) season off the Oregon shelf, and from these a seasonal mean circulation pattern may be pieced together [Huyer *et al.*, 1979; Mooers *et al.*, 1976].

The longshore components of mean velocities are southward at the surface, strong above the inclined density front, and northward below the surface in depths of 100 m or more. The mean velocity of the coastal jet is of the order of 0.3 m/s. The northward flow below is referred to as the poleward undercurrent, and this appears to be trapped over the upper slope in depths less than 500 m.

Cross-shore velocities present a more complex picture and have been the subject of considerable controversy. Some of this was no doubt caused by a confusion of Eulerian and Lagrangian means, an acute problem in an upwelling zone where some fixed point current meters sample widely different water masses in the course of upwelling-downwelling events. What is not in doubt is that over most of the water column the cross-shore velocity is directed shoreward most of the time and has an amplitude of about 2 cm/s. Across the 100-m isobath, this implies onshore transport of about 2 m³/s, or about 3 times more than the offshore Ekman transport at the surface associated with the mean wind stress. There is also some offshore Ekman transport in the bottom boundary layer of the poleward undercurrent, but it is very unlikely that this is sufficient to maintain two-dimensional mass balance by transporting away most of the onshore flow that arrives throughout the water column. Various studies have also convincingly demonstrated that some of the water drawn from deeper levels is heated at the surface and sinks along isopycnals of the pycnocline when the latter intersects the free surface. This implies offshore motion along some isopycnals, but it is not clear whether the quantity is sufficient to affect the cross-shore mass balance significantly.

A long-term mean onshore velocity of about 2 cm/s, constant with depth, implies a longshore sea-level gradient of 2×10^{-7} , driving northward. A longshore gradient of this sign and magnitude may also be inferred from the density field of the North Pacific [Field and Manly, 1976]. In the yearly average, this gradient is confined to latitudes south of 36°N, but in the summer it extends to 44°N, and thus encompasses the Oregon shelf. The cross-shore sea-surface slope associated with the density field extends to about 100 km from the shore, i.e., it coincides with the poleward undercurrent. The longshore sea-level slope is associated with a corresponding pycnocline slope, more or less as in the simple model of Figure 6. The longshore momentum balance of the poleward undercurrent is thus dominated by a northward driving pressure gradient that is balanced in the frictionless interior by onshore flow. Where the onshore flow runs into the continental slope, a northward current develops, with associated bottom friction. The longshore isopycnal slope along the west coast of North America is apparently part of a larger-scale response of the North Pacific to wind stress. The undercurrent transports relatively warm and saline water northward over a considerable range of latitude.

In the surface layers, offshore wind-driven Ekman drift is compensated by onshore flow in a layer of about 30 m depth, i.e., essentially above the main pycnocline. Onshore flow in the deeper layers turns seaward, partly in the bottom boundary layer below the undercurrent, but this circulation is confined only to the trapping width of the boundary current (~60 km), and in any case it is insufficient for two-dimensional

mass balance. The rest of the inflow is presumably accommodated in an intensified boundary current in a rather more complex situation than Figure 6 illustrates but nevertheless in the same general manner.

Conclusion

The later sections of this article have increasingly focused on long-term, larger-scale flow phenomena, which are at best partially understood. The mean circulation problem clearly requires a further study in all three environments discussed here, as well as in even more complex cases, such as semi-enclosed basins. To quote another conspicuous gap in knowledge, the summer circulation over the East Coast continental shelf shows complexities that, at present, appear completely puzzling, including a bottom-trapped cold band of water flowing along the outer shelf, the water supply for which seems to originate in the Gulf of Maine. On the other hand, we seem to possess a fair understanding of short-term transient flow events over the inner shelf.

Incomplete as our present state of knowledge of coastal circulation may be, it clearly provides a much better basis for assessing the environmental impact of various human activities

than was available a few years ago. Present policies and rules of the regulatory agencies do not reflect this, presumably because scientific understanding has not yet been translated into the engineering science of pollution modeling, at least not at the necessary level of sophistication, i.e., focusing on the probabilities of undesirable events rather than on such simplistic measures of nuisance or hazard as the 'mean concentration' of a pollutant, whichever way the mean is defined. It should be well within the realm of possibility to develop the more advanced pollution prediction models required and to distill from the science of coastal circulation the quantitative inputs necessary for these models.

Acknowledgments

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Reflections From the Executive Office Building

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Four years ago, Frank Press came to Washington to take on what amounts to the position of chief scientist for the United States of America. He came to serve a new President as his personal science advisor and to be director of the Office of Science and Technology Policy in the Executive Office of the President. As a new administration takes over in Washington, Frank Press has returned to MIT for a brief respite before assuming, on July 1, 1981, the presidency of the National Academy of Sciences for a 6-year term.

When Frank Press arrived in Washington in early 1977, he was relatively unknown in political circles. He would have to become very well known to the President, to members of the House and Senate committees, to the Office of Management and Budget (OMB), to representatives from industry, and to all departments of the executive branch of government. Frank Press leaves office not only very well known but very well respected as an apolitical human who served effectively among politicians.

His own views of his time in Washington are provided in two recent articles in *Science* magazine (January 9 and 16, 1981). On his last day, in his third-floor office overlooking the north lawn of the White House, Frank Press took time out to describe to us a few of the high points of his last 4 years and to muse on the future for geophysics.

In Washington, Frank Press played two distinctly different but intertwined roles. As the President's science advisor, Frank Press had to put his abilities and those of the scientific community at the service of the President. In this role it is hard to envision a piece of legislation or a regulation that does not require scientific input. It is equally as hard to separate science from economic, regulatory, or defense issues. As director of the Office of Science and Technology Policy (OSTP), Press did not deal primarily with science or scientists but rather with issues that affected science and science policy and with individuals who handle these issues. The rapport he established with OMB contributed heavily to his success. Concepts in government, no matter



Frank Press has been a leader throughout his career. In 1957, at age 33, he became director of the Seismological Laboratory of the California Institute of Technology. He was elected to the National Academy of Sciences in 1958. In 1980 he was named California scientist of the year, and in 1982 he was honored by *Life* magazine as one of the 100 most important young people in the United States. In 1985 he assumed the chairmanship of MIT's Department of Earth and Planetary Science, and he served as AGU president from 1974 to 1978. He has received numerous awards and medals for his scientific achievements.

how noble or valid, become no more than bureaucratic paper if funding does not support them. A sympathetic President and an effective science advisor/OSTP director were behind the fact that science and technology funding fared very well during the past few years.

In addition to issues and concepts the implementation of scientific programs within the federal government and of programs that rely heavily on scientific input were influenced by Press's advice on the selection of key personnel. His quickly established credibility made it automatic to turn to him, and he in turn consistently surveyed the scientific community for opinions and advice both on issues and on personnel. He canvassed individuals and went to various scientific and technical organizations, including societies, for help. Press commented on the role of some of these organizations. Some were effective lobbying groups; others, such as the American Physical Society, prepared excellent analytical reports; and still others were like the AGU, with which he had essentially no formal interaction during his term in the White House. Although societies in the earth sciences have not prepared public policy studies, such as the well-known ones prepared by the American Physical Society and the Academy, he sees that there may be such a role in the future for AGU.

Extraordinarily high-level consideration is required by the far-reaching implications of so many issues that are closely related to science. Press commented on various space missions and about policy-related issues ranging from recombinant DNA to energy policy. Two programs of particular interest to geophysicists are synfuel and ocean margin drilling (OMD). Press noted that the U.S. has sufficient energy resources available but not instantly so. To initiate either significant synfuel production or an ocean margin drilling program, the federal government must support and protect the undertakings. However, neither will function well unless it is ultimately in the hands of industry.

The federal government role is essential because, in the case for synfuel development, for example, an oil cartel could adjust and chop prices in ways that would cripple the incipient industry. In the OMD case the payout is likely to be decades away, and the research could be put off. Industry requires a sharing of the cost if it is to do the work at an earlier stage and thus to bring in knowledge in order to clarify the country's future alternatives. The OMD program would be politically dead today if Frank Press had not been able to bring together government and industry.

The routes by which scientific and technical issues travel from conception to implementation in the government directly influence the outcome. At the highest levels, individuals' backgrounds, skills, and prejudices can become all important. Frank Press was fortunate. His old friend and colleague Harold Brown was secretary of defense, smoothing the way for an extraordinary collaboration in that key area. He was not without other scientific colleagues in high places: for example, AGU members Hans Mark, secretary of the Air Force; Robert Frosch, administrator of NASA; and William Menard, director of the U.S. Geological Survey. Press worked closely with OMB on the science aspects of departmental budgets. He remarked that whenever the secretary of a department, for whatever reason, was behind an issue, the way was clear and everything flowed smoothly. But if for any reason the secretary was not positive, the issue was completely dead. Among the government agencies, Press singled out for special praise the U.S. Geological Survey under William Menard—a highly efficient and thoroughly professional scientific organization that Press feels has received less than the credit due it in the past several years.

In looking at where geophysics is headed in the next few years, Frank Press talked about a golden future, a future full of opportunities in science and opportunities for employment and new careers. He cited the new liaison between geology, geophysics, oceanography, and the planetary sciences and the overriding importance of these areas in dealing with the critical natural resource problems that the nation and the world face. New techniques and scientific discoveries will keep excitement in geophysics at a high pitch for many years. He mentioned specifically the new seismic reflection profiling, such as the COCORP program; hot water circulation in the ocean ridges; the Venus Orbiter Imaging Radar and the Galileo space missions; and high-pressure research as contributing to this excitement. As Press spoke, one sensed perhaps a bit of envy for the young scientist who has before him such extraordinary opportunities to contribute.

In talking to Frank Press one forms a picture of an effective

team with perhaps continually changing players, the President, department secretaries, and advisors, dealing with issues and broad policy matters—sometimes effectively and other times less effectively, but always with the national interest foremost. Much of the work Frank Press undertook was effective because the President cared about science and engineering, and the President understood the importance of considering the input of scientists. Frank Press could communicate with the President: 'The President knows what I mean when I talk about the second derivative going to zero.' The effectiveness of Frank Press's service to the President and his role in strengthening science and engineering, two distinct areas both carried out so well, depended not only on a willingness of those in high places to listen but also on affirmative action. Many of the people who worked with Press during the last 4 years will remain on the White House staff. It is our hope that they will transmit to their new bosses, whether they be economists, lawyers, industrialists, or scientists, the importance of including scientific considerations, of seeking out scientific advice, and of keeping the scientific base on which this country grows healthy. Frank Press has established a fine foundation as the first full-term director of the Office of Science and Technology Policy. It remains to his successors to build upon it. We also expect that his successors will hear from him and that in his new role as president of the National Academy of Sciences, which is truly a role in which one represents science and scientific institutions, geophysicists will have cause to be very proud of one of their own.

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News

Acid Precipitation

Copies of the draft National Acid Precipitation Assessment Plan are available for public comment from the Interagency Task Force on Acid Precipitation. The plan, which outlines a 10-year national research program, is open for comment until April 3. It supersedes an earlier plan proposed by the former Acid Rain Coordinating Committee (ARCC).

The national assessment program aims to identify the sources, causes, and processes involved with what is commonly known as 'acid rain,' i.e., precipitation with a pH less than 5.7. However, the deposition of acidic substances in the atmosphere is not limited to rainy periods; dry deposition also occurs. Major processes for dry deposition are gravitational settling of coarse particles, impaction of particulate aerosols, and the absorption or adsorption of gases.

Sulfur and nitrogen oxides, emitted from automobiles and coal- and oil-burning power plants, usually take the blame for causing the increased atmospheric acidity. This has prompted some to claim that acid rain is a local or regional problem. Preliminary measurements at remote islands in the Pacific and Indian oceans, however, indicate that acid rain may be a global phenomenon.

Acid deposition was tackled by the ARCC, which was established by President Carter's environmental message in August 1979. In September 1980, the committee issued draft copies of its 10-year plan. Two months before that draft was issued, the Acid Precipitation Act of 1980 was signed into law, creating the Interagency Task Force on Acid Precipitation, composed of 12 federal departments and agencies. In November the new task force incorporated ARCC and, using the ARCC 10-year plan as a baseline, began drawing up a new plan on acid rain research.

The task force's draft is 'less strident and has a more balanced tone' than the ARCC preliminary plan, according to Chris Bernabo, executive secretary of the Interagency Task Force. The new draft also makes fewer assumptions and places 'greater emphasis on uncertainties' about acid deposition, he said. In addition, more attention is given to understanding the atmospheric processes involved in the transportation, transformation, and deposition of acidic materials within the atmosphere, noted Bernabo, who was also the AGU Congressional Science Fellow in 1978-1979.

Nine research tasks are the focus of the plan. Each has a lead agency, with funds budgeted expressly for research, and each has agencies that contribute to the work. NOAA leads two of the nine: The agency is charged with leading the research on analysis and assessment of natural resources of acid deposition and the research on atmospheric processes. The Environmental Protection Agency (EPA) leads research on aquatic impacts of the acid deposition, control technology, and the assessments and policy analysis. The Department of Energy is stated as the lead agency to research man-made sources, while the Department of the Interior heads the work on the deposition monitoring of acid substances and on the effects on materials. Research on terrestrial impacts is assigned to the Department of Agriculture.

Copies of the draft can be obtained from Chris Bernabo, Executive Secretary Interagency Task Force on Acid Precipitation, Council on Environmental Quality, 722 Jackson Place, N.W., Washington, D.C. 20006. All comments on the draft plan should be directed to Bernabo.

The task force is cochaired by NOAA, the Agriculture Department, and EPA. Also participating are nine other federal departments and agencies: the Departments of Commerce, Energy, Interior, Health and Human Services, and State, the Council on Environmental Quality, NASA, the National Science Foundation, and the Tennessee Valley Authority.—BTS

H Gas: Captured at Last?

In the strange world of low-temperature physics, few more unusual phenomena have been discovered than monatomic hydrogen gas. According to a recent report (*New Scientist*, Jan. 1981, p. 204), hydrogen atoms do not tend to pair up to form molecules under special low-temperature-cryogenic experimental conditions. The reasons for the existence of atomic hydrogen gas at ultra-low temperature, and for its implications, lie in an understanding of its almost pure quantum mechanical properties. Practical uses of atomic hydrogen will await more knowledge of its properties, but right now, if available in sufficient abundance, atomic hydrogen could be used in mass clocks because it emits highly defined frequencies of microwave radiation at room temperature, and atomic hydrogen gas could be used as an energy conservative fuel, as it recombines to the diatomic molecule. For every recombination between two hydrogen atoms, 4.5 eV of energy are released, which calculates to be over 1 million watts of power per second for 10 grams of atomic hydrogen recombined. The large impulse relative to its light mass could be significant in applications of atomic hydrogen recombined. Practical applications aside, the main interest in atomic hydrogen at this moment is in the insight into quantum mechanics that study of its properties may provide. Atomic hydrogen atoms 'abound throughout the universe,' even though not on Earth, and thus quantum effects in space, and the hydrogen-rich planets as well, may be elucidated by results of these studies.

Silvera and Walraven describe helium at low temperatures as almost ideal from a quantum standpoint, but not quite (*New Scientist*, U.S.). Monatomic helium remains only as liquid to temperatures as close to absolute zero as attainable. In the cryogenic range between 2.18 and 0 °K, li-

uid helium (helium I) changes into the so-called superfluid state (helium II).

Helium II is difficult to contain as it tends to creep up the walls of its container and dribble away. The superfluid flows without viscosity or damping and can pass through small holes and membranes that are impermeable to other liquids. The superfluid state is evidently the finite temperature ground state of zero momentum predicted theoretically by Einstein, and thus study of the properties of liquid helium that has 'condensed' into the superfluid state could offer a unique examination of quantum theory. Problem is, superfluid helium atoms interact strongly, and the interactions prevent analogy with theoretical quantum states. Modern theory cannot provide a description of a strongly interacting liquid such as helium. Monatomic hydrogen, however, could provide a better case for comparison with numerous theories.

The importance of the availability of atomic hydrogen gas in the laboratory is that the results of its study may allow a definitive experimental verification of the relation between the superfluid state and the state predicted by Einstein (known as Bose-Einstein condensation). Hydrogen is predicted to remain a gas, even at 0°K. Being a gas, its density can be reduced so that the interactions between atoms are weak enough to place its behavior within the precepts of modern theory.

Atomic hydrogen actually has been known for many years in the laboratory, but in a highly unstable form produced by the dissociation of molecular hydrogen in an electrical discharge. The new process of producing atomic hydrogen utilizes a magnetic field that draws the atoms like a bar magnet; those with the lowest energy state are drawn to the strongest portion of the field. The process feeds hydrogen atoms from an electrical discharge into a cryogenic cell placed with a superconducting magnet. The hydrogen gas can now be held in the cell for indefinite periods.

The experiments with atomic hydrogen are still in their infancy. It has not been possible yet to produce a gas dense enough to have superfluid properties that are amenable for study. What is being attempted is to increase the density by a factor of 10. When that happens, the fruits of this breakthrough may be realized.—PMB

Are There Options for Nuclear Waste?

The problems of storage of nuclear wastes are reaching crisis proportions. Although conceding that a measure of the crises has been caused by the 'enormous emotion' of 'protesting green ecologists,' (*ISR, Interdisciplinary Science Reviews*, 5(4), 1980), the bottom line is that nuclear wastes have been and continue to be dumped into the oceans and scattered in leaking and leakable containers on the surface. There is a fear among members of the nuclear engineering community that the U.S., under recent government restrictions, has placed itself in a compromising position on the development of nuclear power facilities. One area of concern is that of nuclear waste disposal. Other countries are subject to the same problems and fears. For example, in the Federal Republic of Germany the term 'Enstorgungszentrum' has been coined to describe the total process of reprocessing and disposal of spent nuclear fuel elements. The concern is that spent fuel continues to accumulate because restrictions and laws have affected efforts to resolve the problems of reprocessing and disposal. Right now the environment is subject to damage from the inadequate storage practices of the past. Geoscientists working on the problem of waste disposal await the answers to questions about the projected quantity of waste to be disposed. The options to be explored depend on the volumes to be handled.

Recently, an official of the Department of Energy estimated that the total amount of radioactive waste from nuclear power plants that exist now could fill only the area of a football field, stacked to a height of 10 feet. This appears to be an unexpectedly small volume of material, but not included in this estimate are the huge volumes of military wastes. Furthermore, emotional protests aside, if the construction of nuclear power plants does increase markedly, the volume of wastes will be much larger. In any case, even the most extreme estimates suggest that the amounts of radioactive waste are manageable.

The necessary number of half-lives for which radioisotopes must be stored is on the order of a 'geologic time scale,' so the options for storage must necessarily involve indefinite time protection factors. One obvious option is to store the waste in space (*Spaceflight*, 22(182), 1980), where thousands of years of stability should be no problem. The safety factors involved in getting the wastes into space are in question, however, as are the costs. It is important to realize that the risks of handling nuclear power plant materials in conventional operations are very low, even by comparison with the risks of handling other materials (op. cit.). The conclusion, based on current wisdom, is that it will be safe to store the wastes on the surface or in the ground.

A preliminary step in storing nuclear wastes is known as reprocessing; this step is also banned in the U.S. at this time. Reprocessing is a concentration and separation technique to remove some isotopes (especially Pu^{239}) for reuse and to separate high-level from low-level radioactive wastes. Although this step involves the risk of making nuclear materials that would present a potential danger if they fell into the wrong hands, it is thought by some to be a crucial step in disposal planning. One option in the storage scheme for all wastes is to incorporate them in a glass host or crystallize the waste into synthetic mineral structures ('SYNROC'). The purpose is to form a synthetic material

that has both high chemical resistance and favorable thermal and other physical properties. As with the other stages of spent-fuel reprocessing, continuing research on synthetic host materials is needed.

Considering the constraint that nuclear wastes must be stored and isolated safely for at least 1000 years, it would appear that the choices are few, but this is not necessarily true. Surface (or slightly subsurface) storage is a viable option. There are and will be many types of concentrated radioactive materials located on the earth's surface. It might be argued that they would be in the way of human progress and would be too accessible. Improved canisters of synthetic rock could be kept under control, however, and knowledge of their existence could be transmitted to future generations. Their very accessibility could be an important factor, not only in their safety but in their possible future reuse, when and if more economical isotope separation methods are developed. The difficulty lies with the 'human factors,' particularly public acceptance of almost visible storage practices.

'In or under the surface' includes land, oceans, and ocean floors. The practice of allowing liquid radioactive wastes to flow directly into the sea would appear to be completely unacceptable at all levels. Containment, even in its present state of development, is so much safer. It may be possible to drop projectile-shaped containers into the ocean to penetrate the sediment. There are suggestions, currently under consideration, to place waste-filled containers in holes drilled through the ocean sediment into basalt. The environmental impact of all ocean storage schemes may be unacceptable, however. Perhaps the best alternative for underground storage known today may be in stable geologic formations such as salt domes, as was first tried in the U.S. in the 1950's.

The domes are known to persist stably for hundreds of millions of years and the salt seals out the intrusion of groundwater. Caverns excavated in salt domes last indefinitely, and the salt itself, being a good thermal conductor, is a favorable sink for radioactive heat. According to a recent report (*ISR, Interdisciplinary Science Reviews*, loc. cit.) of tests done at the Asse abandoned salt mine in Germany, totally reliable techniques exist for the safe disposal of wastes of all levels of radioactivity.

It appears clear that, barring public outcry and government intervention, the path to safe storage of nuclear wastes is straightforward, and the best options are beneath the surface, either in salt mines or in the shafts of excavated rock formations. Continuing research on reprocessing of wastes, including the incorporation of separated fractions in synthetic rock or glass; on the geology, geophysics, geochemistry, and hydrology of suitable sites; and on the storage containers will be needed to provide data as the storage builds.—PMB

NACOA Vacancies Filled

Six scientists were recently appointed to the President's National Advisory Committee on Oceans and Atmosphere (NACOA) as part of the committee's normal rotation, according to Steven Anastasio, executive director. Two of the six positions were reappointments.

The committee, consisting of 18 scientists not working in the government, advises the executive and legislative branches on federal programs dealing with the oceans and atmosphere. Each member serves for 3 years; six positions become vacant each year as part of the rotation system. The committee meets about every 6 weeks. Currently under consideration is an evaluation of the role the oceans play in waste-management strategies, Anastasio said. In addition, NACOA will examine national goals and objectives of research and management of the oceans and atmospheres.

Warren W. Washington, chairman of the IUGG Subcommittee for the International Association of Meteorology and Atmospheric Physics, was reappointed to a second term on NACOA. Also reappointed was Sharron Stewart, commissioner of the Texas Deep Water Port Authority.

The four new appointees are Burt Keenan, chairman of the board and chief executive officer of Offshore Logistics, Incorporated, in Louisiana; Jay Lanzillo, industry representative of Chatham Seaford Corporation in Massachusetts; George Tapper, president of Tapper and Company in Florida; and Charles Warren, president of Charles Warren Associates in California. Warren was the first chairman of the Council on Environmental Quality under President Carter.—BTS

Saving For a Rainy Day

Critics of solar energy repeatedly point to the technology's ineffectiveness at night or during cloudy days. Proponents argue that storage systems can provide the necessary backup, but the critics counter that the development of storage systems will slow solar energy's growth and add to the already high cost per kilowatt. Now a National Research Council committee adds its voice to the chorus.

The Solar Panel of the Committee on Advanced Energy Storage Systems says that the need for storage systems will not delay solar energy development. Present growth for most applications can proceed in the short run as expected. Delays may occur, however, with stand-alone 'electricity-generating systems, which are not connected to a utility network.'

Because solar energy relies on the sun, certain regions of the United States that do not continuously attract sun worshippers could not depend on the technology as a con-

stant and sole energy source; nighttime energy demands also require some backup or storage system. Storage is now limited to facilities that use excess power in off-peak hours to pump water into reservoirs. That water is then released to turn hydroelectric turbines when demand for electricity is high. Geography limits this type of storage.

The Department of Energy's ongoing R&D programs on such technologies as underground pumped hydro, compressed air, and advanced batteries will, if successful, facilitate the market penetration of solar-derived electricity, the committee says in a recent report. More utilities would then be able to install storage systems.

The committee recommends that storage R&D efforts be focused on long-term options that will be responsive to both the economic and technical requirements of high-solar-penetration energy systems. More knowledge is needed, in the committee's opinion, about the social factors—public preferences or perceptions—that could influence the acceptance of solar energy and storage systems.—BTS

Mountain Research

The newly incorporated International Mountain Society (IMS) will in May begin publication of an interdisciplinary scientific journal, *Mountain Research and Development*. The quarterly will be copublished with the United Nations University; additional support will come from UNESCO.

A primary objective of IMS is to 'help solve mountain land-use problems by developing a foundation of scientific and technical knowledge on which to base management decisions,' according to Jack D. Ives, president of the Boulder-based organization. 'The Society is strongly committed to the belief that a rational worldwide approach to mountain problems must involve a wide range of disciplines in the natural and human sciences, medicine, architecture, engineering, and technology.'

'Mountain,' as used by the new society, covers a lot of ground. They interpret the term to include uplands and steep slopes at lower elevations, as well as the peaks and ranges.

IMS expects to prepare an inventory of institutions conducting research on mountain areas and a register of individuals possessing what the society judges as the professional, technical, and/or scientific skills applicable to mountain environments.

Officers of IMS include the president and two vice presidents: Cornelie Jast of France and Heinz Löffler of Austria. A council of scientists, engineers, architects, and administrators also guides the society.

For information about membership and journal subscriptions, contact IMS, P.O. Box 3148, Boulder, Colorado 80307.

Geophysicists

Thomas M. Donahue, chairman of the department of atmospheric and oceanic sciences at the University of Michigan, was awarded the Arctowski Medal by the National Academy of Sciences 'in recognition of his fundamental contributions to understanding the role of solar radiations in the physics and chemistry of the atmospheres and ionospheres of the Earth, Mars, and Venus.' The medal accompanies a \$5000 prize.

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Frederick

Doyle G. Frederick will serve as acting director of the U.S. Geological Survey until a new director is selected. He joined the USGS in 1973 and has served as associate director since February 1980. He has also been the associate chief of the survey's National Mapping Division.

Donald F. Gatz has been appointed head of the new atmospheric chemistry section of the Illinois State Water Survey. He is a member of the statistics faculty at the University of Illinois.

James P. Gibb has been appointed head of the new groundwater section of the Illinois State Water Survey. He joined the Water Survey in 1986.

Gerald J. Wasserburg, at the California Institute of Technology's division of geology and planetary sciences, was awarded the Arthur L. Day Prize and Lectureship by the National Academy of Sciences in recognition of his work with isotopes, studying geophysical problems of the solar system.

The following reports changes in the executive staff of the American Meteorological Society (AMS) and reports awards presented at the annual awards banquet in San Diego.

Richard E. Hallgren, director of the National Weather Service, National Oceanic and Atmospheric Administration, has been chosen president-elect of AMS. He will assume office in 1982.

Robert G. Fleagle, atmospheric sciences professor at the University of Washington in Seattle, is the incoming AMS president. He succeeds Robert M. White, president of the University Corporation for Atmospheric Research.

The five councilors elected to 3-year terms of office are: James Philip Bruce, assistant deputy minister of the Environmental Management Service, Fisheries and Environment Canada; Edward M. Carlstead, chief of the Forecast Division, National Meteorological Center of the National Weather Service; David S. Johnson, assistant administrator for satellites, NOAA; Norman J. Rosenberg, professor and director of the Center for Agricultural Meteorology and Climatology, Institute of Agriculture and Natural Resources, University of Nebraska at Lincoln; and Stanley L. Rosenfeld, director of the National Hurricane Research Laboratory, NOAA.

Roscoe R. Braham, Jr., was awarded the Carl-Gustaf Rossby Research Medal, the highest honor accorded by AMS. The professor in the Department of Geophysical Sciences at the University of Chicago was selected 'for his notable contributions in research and effective leadership in the study of complex convective systems.'

Sediment Transport/Geological Oceanography, North Carolina State University. A tenure track position is available in the Department of Marine, Earth and Atmospheric Sciences at the level of assistant or associate professor. Applicants should have a thorough understanding of sediment transport, and a general background in geological oceanography. A Ph.D. is required. The candidate will be expected to strengthen the graduate teaching and research programs. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of marine sediment transport. Applicants should forward a resume, including a list of courses taken, and the names of at least three references to Dr. Charles A. Nittrouer, Chairman, Search Committee, P.O. Box 2688, NC State University, Raleigh, NC 27650. Application materials should be sent by March 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, geophysics or a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant. Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523(303) 481-6265. Deadline for receipt of applications is April 15, 1981. CSU is an EOE/AA, E.O. Office; 314 Student Serv. Bldg.

Thomas H. Vonder Haar, professor and head of the Department of Atmospheric Sciences at Colorado State University, and Charles D. Keeling, oceanography professor at the Scripps Institution of Oceanography, shared the Second Half Century Award.

Jerome Namias, an oceanographer at Scripps, received the Sverdrup Gold Medal 'for his studies of the ocean's role in climatic variability. His long-term dedication to large-scale, all-sea interaction and inspiring leadership has laid the basis for present progress.'

Stanley A. Changnon, Jr., chief of the Illinois State Water Survey, received the Cleveland Abbe Award for his work on the impacts of weather and climate on humanity.

Charles L. Hosler, Jr., received the Charles Franklin Brook Award for outstanding services to AMS. He is a meteorology professor and dean of the College of Earth and Mineral Sciences at the Pennsylvania State University.

Julian P. McCreary, Jr., an assistant professor of physical oceanography at Nova University's Ocean Sciences Center in Dania, Florida, received the Editor's Award for his reviews of manuscripts submitted to the *Journal of Physical Oceanography*.

William M. Frank was chosen as the recipient of the Banner I. Miller Award for contributions to the science of hurricane and tropical weather forecasting. He is an assistant professor in the Department of Environmental Sciences at the University of Virginia.

New Publications

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Sedimentation in Oblique-Slip Mobile Zones, Spec. Publ. 4 Int. Assoc. Sedimentol., P. F. Ballance, H. G. Reading (Eds.), Blackwell Scientific Publications, Boston, Mass., vi + 265 pp., 1980.

Soil Chemistry, H. L. Bohn, B. L. McNeal, G. A. O'Connor, John Wiley, New York, xiv + 329 pp., 1979, \$19.95.

Stratigraphic Lexicon of Libya, Bull. 13, S. Banerjee, Industrial Research Centre, Socialist People's Libyan Arab Jamahiriya, Tripoli, xviii + 300 pp., 1980.

Thunderstorms, Develop. Atmos. Sci. 12, C. Magono, Elsevier, New York, x + 261 pp., 1980.

The Upper Cretaceous-Tertiary Formations of Northern Libya: A Synthesis, Bull. 12, M. F. Megerisi, V. D. Mangan, Industrial Research Centre, Socialist People's Libyan Arab Jamahiriya, Tripoli, x + 85 pp., 1980.

U.S. Earthquake Observatories: Recommendations for a New National Network, National Academy Press, Washington, D.C., xvii + 122 pp., 1980.

Volcanoes, R. Decker and B. Decker, W. H. Freeman, San Francisco, Calif., ix + 244 pp., 1981.

Water Resource Systems Planning and Analysis, D. P. Loucks, J. R. Stedinger, D. A. Hall, Prentice-Hall, Englewood Cliffs, xiv + 559 pp., 1981, \$29.95.

Western Water Resources, Coming Problems and the Policy Alternatives, Federal Reserve Bank of Kansas City, Westview, Boulder, Colo., 1980, \$25.00.

Structural Geologist/University of California, Santa Barbara. Applications are invited for a tenure track appointment in structural geology to be filled during 1981-1982, subject to availability of funds. Rank dependent upon qualifications and experience. Rank preference will be given to the assistant professor level. Successful candidates must have a Ph.D. degree and strong desire and commitment to teach and direct M.A. Ph.D., and undergraduate students in both structural and field geology. He/she will be expected to develop a strong research program and obtain outside funding for its support. Additional duties may include teaching physical geology and summer field geology.

Please send resume and evidence of teaching and research proficiency, by March 31, 1981, and arrange for early submission of four letters of recommendation to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. (805) 961-3156. The University of California is an affirmative action equal opportunity employer.

Physical Oceanographer/Geophysical Fluid Dynamist

Arete Associates, a growing research firm, located in Southern California, engaged in theoretical and empirical physical oceanography, is offering permanent, full-time positions. Candidates require Ph.D. (or equivalent experience) in physical oceanography or geophysical fluid dynamics. Salaries are competitive and negotiable, based on qualifications. Arete offers a fringe benefit package of superior quality. Qualified candidates should send resume, salary history, and list of professional references to:

Personnel Administrator
Arete Associates
P.O. Box 280
Encino, CA 91436

An equal opportunity employer M/F.

Physical Oceanographer. The Department of Marine Science and Engineering, North Carolina State University, has an immediate opening for a postdoctoral research associate. Research will be directed toward equatorial circulation dynamics, including seasonal and higher-frequency variability. Participation in fieldwork will be required. Qualifications include a Ph.D. or equivalent in physical oceanography or geophysical fluid dynamics and experience in the analysis of oceanographic time series. The initial appointment will be for 2 years, with a possible continuation subject to availability of funds. Salary is competitive and negotiable, based upon qualifications. Applicants should send the names of three references, a resume, and publication list to Robert H. Weisberg, Department of Marine Science and Engineering, P.O. Box 5923, NC State University, Raleigh, NC 27650.

Faculty Position: University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure track faculty in August 1981. Research specialties for which substantial resources are available are in astrophysics and auroral physics and space and laboratory plasma physics, both theoretical and experimental. Other specialties of interest are astronomy, astrophysics, elementary particle physics, atomic physics, condensed matter, and low energy nuclear physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a resume, a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity affirmative action employer.

Meteorologist/Remote Sensing. Immediate opening for meteorologist interested in investigating retrieval and modeling of sea surface temperatures and other ocean meteorological parameters from microwave data. Candidates must have post graduate training in meteorology and interest in remote sensing. Salary negotiable depending on experience. Send resumes to: Roger Smith, Manager of Staffing, Systems and Applied Sciences Corporation, 5811 Kenilworth Avenue, Riverdale, MD 20640. An equal opportunity employer.

Seismologist. The Tennessee Earthquake Information Center (TEIC) is seeking applications for the position of seismologist beginning July 1981. The position will also be a joint tenure track appointment in the Department of Geology. Primary duties, however, are with TEIC; teaching will be on a limited basis, not to exceed one course per semester.

The Ph.D. is required and experience with telemetry networks is highly desirable. The successful applicant will be expected to assume co-PI responsibilities on the Memphis and Southern Appalachian seismic networks, as well as actively pursue externally funded research projects in digital data processing, seismic hazard assessment and public information are other aspects of the job.

The TEIC is a research organization of Memphis State University and the State of Tennessee, 12-month salary (\$25,000 and above) depends on background and experience. Position is 1/2 state supported, 1/2 (summer) from external sources. Application deadline: 15 April 1981. Send resume, publications list, short statement of research interests, and names and addresses of four referees to:

Arch Johnston, Director
Tennessee Earthquake Information Center
Memphis State University
Memphis, Tennessee 38152
Memphis State University is an equal opportunity affirmative action employer.

Postdoctoral Research Associate. Oceanography Department of the Naval Postgraduate School seeks recent graduate to study the hydrodynamics, through numerical ocean modeling of the physical oceanographic processes active in the vicinity of the arctic ice edge of Alaska. Problem areas include the effects of the complex bathymetry on the circulation and frontal formation, the dynamics associated with intruding water masses at the ice edge, and the mechanisms involved in ice retreat. Research will be performed in the context of an observational program which has acquired data and developed insights over the course of several years. Position is available March 1981 and is renewable annually. Salary depends upon qualifications. Send resume and the names and addresses of three references to Faculty Search Committee, Dept. of Oceanography, Naval Postgraduate School, Monterey, CA 93940. Equal opportunity/affirmative action employer.

Von Braun Post-Doctoral Fellowship in Space Physics/University of Alabama in Huntsville. Appointment effective September 1981 in a tenure track assistant professorship with reduced teaching load during the first two years. Research specialty is in geophysics, planetary science or solar terrestrial physics. Research support available from UAH, NASA and Padelon Arsenal. Salary competitive. Recent Ph.D.s are invited to send resumes, research plans and names of four references. Apply to: Von Braun Fellowship Committee, Office of Academic Affairs, University of Alabama in Huntsville, AL 35899.

Equal opportunity in education and employment.

Solid Planet Geophysicist/Texas A&M University. The Department of Geophysics at Texas A&M University is pleased to announce availability of a junior level, tenure track faculty position. The department emphasizes solid earth geophysics with concentrations in tectonophysics, geodynamics and internal structure. We are seeking a talented and active researcher and teacher who will complement, strengthen, and broaden current areas of expertise. There are excellent opportunities for interaction and collaboration with members of our department as well as those in the departments of oceanography and geology and in the center for tectonophysics. Qualified scientists are requested to send resumes to Neville L. Carter, Head, Department of Geophysics, Texas A&M University, College Station, TX 77843.

Texas A&M University is an equal opportunity employer.

Postdoctoral Appointee. Applications are invited for a recent graduate to perform research on the exchange of gases and fine particles between the atmosphere and the surface of the earth. A Ph.D. in meteorology or a related discipline is required and strong research interests in experimental meteorology, electronics, and computer programming is needed. The individual will join a closely-knit research group operating under DOE and EPA sponsorship. Please send resume to: Mr. Mickey Brown, Box RER-80, Argonne National Laboratory, 9700 So. Cass Avenue, Argonne, IL 60439.

An affirmative action/equal opportunity employer. Women minorities, the handicapped and veterans urged to apply.

Groundwater Hydrologist and Associate Assistant Professor, tenure-leading. Develop and conduct a strong research program (75%) in groundwater hydrology as related to irrigation. Perform research on the effects of various irrigation management programs on soil water movement and groundwater storage. Might include modeling the hydrologic system associated with the unsaturated volume below the crop rooting zone as well as the water saturated portion. Also teach (25%) two advanced groundwater hydrology courses and basic descriptive hydrology courses. Requires Ph.D. in engineering, hydrology, geology or related field with strong background in mathematics, flow in porous media, computer science, groundwater hydrology, optimization and irrigation. Apply with resume and three names of references by April 1 (or until suitable candidate is found thereafter) to: Dr. William L. Powers, Director, Nebraska Water Resources Center, 310 Agricultural Hall, The University of Nebraska-Lincoln, Lincoln, NE 68583. Affirmative action/equal opportunity employer. (402) 472-3305.

Structural Geologist. The Department of Geosciences of Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geological group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three references, and a brief statement of research interests to R. H. McCauley, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirmative action employer.

Program Manager/Meteorology. Oceanographic Services, Inc., is seeking qualified applicants for the position of program manager for meteorological studies. Applicants should have an M.S. or Ph.D. in meteorology or atmospheric sciences, plus experience in the field. A broad general knowledge of air pollution, and an understanding of the air pollution regulatory environment, is helpful. Interested persons should send resume, references, and salary history to R. C. Banks, Oceanographic Services, Inc., 25 Castilian Drive, Galesburg, IL 61231.

Geophysicist North Carolina State University—Raleigh. The Department of Marine, Earth and Atmospheric Sciences invites applications for a presently available tenure track position in geophysics. Rank and salary are open. Ph.D. is required. Applied or exploration geophysics orientation are preferable; however, other specializations in geophysics also will be considered. Primary responsibilities will include generating and conducting research programs as well as departmental teaching courses in geophysics. The faculty member will be expected to teach in the areas of geology and geophysics. Please send resume and names of three references to: Dr. J. J. Wron, Search Committee Chairman, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27650, USA. We hope to make a final decision prior to May 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Seismologist and Specialist in Rock Deformation Science: Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Johannesburg, South Africa. Applications are invited from suitably qualified persons, regardless of sex, race, religion or nationality, for appointment to the above posts. Mines in the Witwatersrand Gold Fields are now penetrating to depths of 4 km. The confining strata are strong quartzites. Between 1971 and 1977 the Institute had an active programme of investigating the seismic events which accompany the deep mining. Many seismological studies were published on these events. Occasionally tremors have exceeded a magnitude 5.0 on the Richter Scale and in recent years there have been ten events between M = 4.0 and 4.8. Source mechanisms are similar to those of small shallow earthquakes.

One of the Institute's publications (by Gay and Orieppe) describes a region where a seismic event occurred in advance of active mining. Special excavations were created to examine the failure zone and it was possible to ascertain in some detail the structure of this volume of failed rock.

There are heavily instrumented seismic networks—some completely digital—in four of the mining areas. Mine safety records are comparable with major industrial operations on surface. The University is now renewing its researches on the seismic source mechanism and its implications. We seek a seismologist and a specialist in rock deformation science, to lead further researches in this important sphere, and to collaborate with institutions and University Departments elsewhere in the world who have a special interest in the mechanics of shallow earthquakes. The salary is negotiable, depending on qualifications and experience. Applications should reach the Director, Bernard Price Institute (Geophysics), University of the Witwatersrand, Jan Smuts Avenue, Johannesburg 2001, South Africa before 31 March 1981; further information on this post may be obtained from him.

Geochemistry/Brittle Deformation, University of New Brunswick. The Department of Geology has a tenure track position available from July 1, 1981 at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students.

Applications will be accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or site engineering.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three references should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Faculty Position: Petrology Tectonics. The Department of Geology at Stanford University has an opening for a full professor to work half-time in the fields of petrology and tectonics. We seek someone who is interested both in teaching and in conducting research on the petrology and tectonics of continental margins. Applicants are invited to send letter of application, a resume and the names of three references by March 31, 1981 to:

Allen Cox
School of Earth Sciences
Stanford University
Stanford, CA 94305

As an equal opportunity and affirmative action employer, Stanford welcomes applications from women and minorities.

Queens College. Position for 1-2 years as assistant replacement starts September 1981. Specialties requested: geochemistry (organic, environmental, or exploration); exploration geophysics; groundwater geology. A Ph.D. required. Applications should include cv, and three references. Send to: D. H. Spedell, Department of Earth and Environmental Sciences, Flushing, NY 11367.

Queens College is an affirmative action/equal opportunity employer.

Sedimentology: University of Minnesota. The Department of Geology and Geophysics invites applications for a temporary faculty position in recent sediments starting September 1981. This is likely to become a tenure track assistant professor position starting fall 1982. Opportunities exist for interaction with the Limnological Research Center and with active research programs in paleogeology, paleomagnetics, hydrogeology, and low-temperature geochemistry, as well as with the St. Anthony Falls Hydraulic Laboratory. Ph.D. and strong interest in research are required. Resume, statement of research interests, transcripts, and three letters of recommendation should be sent by March 28 to:

Dr. Anita L. Crews
Sedimentology Search Committee
Department of Geology and Geophysics
University of Minnesota
108 Pillsbury Hall
Minneapolis, MN 55455

The University of Minnesota is an equal opportunity employer and employer and specifically invites and encourages applications from women and minorities.

Director Meteorology Division, Air Force Geophysics Laboratory. Air Force Geophysics Laboratory invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts. The Division is responsible for Air Force research and development in meteorology, atmospheric physics, remote and direct sensing technology, climatology and related technologies. The division director provides overall direction to an R&D program which employs over 80 people and covers a broad range of in-house and contractual scientific investigation. A candidate should have a record of distinguished achievement in meteorology/atmospheric physics as a research scientist and manager of a substantial R&D unit. Title position is Air Force Senior Executive Service with a salary range of \$52,247 to \$67,673, subject to current \$50,112 ceiling. For an application package, call collect: Robert E. Elin, (617) 81-2899. To be considered, applications must be received by 30 April 1981.

Equal opportunity/affirmative action employer.

Faculty Position Economic Geology

The Department of Geology, University of Georgia, has a tenure track opening in economic geology. Rank and compensation are open through the associate professor level.

Duties include (1) teaching courses in exploration geochemistry (2) supervising M.S. and Ph.D. candidates, and (3) developing a strong research program with significant field commitment.

Teaching and research interests in one or more additional fields such as ore deposit mineralogy, reflected light microscopy, theoretical geochemistry of ore deposits, fluid inclusion research, hydrogeochemistry, or environmental geochemistry are desirable.

An applicant should submit a detailed curriculum vitae and have at least three letters of recommendation sent to F. Donald Eckelmann, Head, Department of Geology, University of Georgia, Athens, Georgia 30602. The deadline for receipt of applications is May 1.

The University of Georgia is an equal employment opportunity/affirmative action institution.

Postdoctoral Fellowship in Experimental Petrology at UCLA. Starting approximately September 1, 1981, an up to 24-month appointment in phase equilibrium research, chiefly hydrothermal synthesis, will be available. Candidates should possess Ph.D. Send letter of application and arrange for two confidential recommendations to be forwarded to: W. G. Ernst, Earth and Space Sciences, University of California, Los Angeles, California 90024.

UCLA is an equal opportunity/affirmative action employer.

Upper Ocean Modeler. Two postdoctoral positions in upper-ocean modeling available in the mesoscale air-sea interaction group at the Florida State University, Ph.D.'s with background in fluid dynamics, theoretical physical oceanography, dynamic meteorology, numerical analysis, or physics are invited to apply. Salary range \$18,000—\$21,500/year. Positions are supported by Office of Naval Research and may be filled at any time after April 1, 1981. Send vitae and names of three references to Professor James O'Brien, The Florida State University, Tallahassee, FL 32306.

The University is an equal opportunity employer.

Dean of Sciences and Mathematics/Hunter College, City University of New York. Challenging position available July 1981, in dynamic urban institution. Strong doctoral research programs, extensive federal funding, major commitment to women and minorities, MSB and MARC programs, stable enrollments, major expansion of facilities in progress, attractive midtown Manhattan location. Send resume and names of three references to Chair, Search Committee for Dean of Sciences and Mathematics, Box 447, Hunter College, 685 Park Avenue, New York, NY 10021.

Research and Data Systems, Inc./Scientific Programmers and Programmer Analysts. Immediate openings for persons with B.S. in science or math and at least two years experience with FORTRAN or PL/I on IBM systems. Work involves data processing and analysis from satellite based remote sensing systems. Experience with time sharing systems preferred. Also have openings for staff scientists with strong programming background. Send resume in confidence to Research and Data Systems, Inc., 9420 Annapolis Road, Lanham, MD 20801. Telephone: (301) 459-0001.

Geophysicist/Structural Geologist, Albion College. A tenure track position, commencing Fall 1981, is open at the assistant professor level at Albion College's Department of Geological Sciences. The position involves teaching undergraduate laboratory courses in structural geology and geophysics and introductory lab courses or field camp in geology. The Department is developing a geophysics major and has some geophysical equipment. Candidates with a Ph.D. or who are about to acquire a Ph.D. are preferred.

Depending upon the applicant's background, the new staff member may have the opportunity to assist in teaching at Albion's geology field camp for additional remuneration. A 8-week summer field methods course is offered to students from many colleges and universities at the field camp located in the Front Range near Boulder, Colorado.

Albion College is a co-educational liberal arts college located in southern Michigan, an hour's drive from Michigan State University. The University of Michigan and Western Michigan University. The Department has four staff members and 30 to 40 majors; it is a well-equipped department occupying a floor-and-a-half of a new science center.

Resume, transcripts and three letters of reference should be submitted to: Prof. Lawrence D. Taylor, Department of Geological Sciences, Albion College, Albion, Michigan 49224.

Albion College is an equal opportunity employer.

Exploration Geophysicist/University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will hire an experienced exploration geophysicist to fill the Frank and Betty Schulz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schulz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences. To be housed in a new building, The School of Geology and Geophysics will expand from its present faculty of 16 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry, petrology, and energy resources.

State geothermal resource maps of Washington, Montana, North Dakota, Texas, Oregon, Arizona, Nevada, Wyoming, Virginia, Nebraska, Alaska, Kansas, Oklahoma, and Hawaii will follow in the future.

If you wish to obtain these products, send your name or card, your affiliation, and your address to: NOAA/NGSDC, Data Mapping Group, Code D64, Boulder, CO 80503.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma is an equal opportunity employer.

Oceanographic Mooring Technician. The Marine Science Program at North Carolina State University (Raleigh) is expanding its oceanographic technical services group and is currently seeking a technician familiar with the design and deployment of deep-sea current meter mooring arrays, as well as with standard shipboard oceanographic sampling techniques.

Qualifications include a degree in science or engineering with some electronics background and two years field experience or an equivalent combination of education and experience. Salary commensurate with education and experience. Send resume and names of references to Personnel Services, North Carolina State University, P.O. Box 5567, Raleigh, NC 27650.

An equal opportunity employer.

SERVICES

Geothermal Resource Maps. The Department of Energy, Division of Geothermal Energy (DGE), in cooperation with NOAA's National Geophysical and Solar-Terrestrial Data Center, announces the publication of geothermal resource maps of Idaho, Colorado, Utah, New Mexico, and California, as well as a "Thermal Springs List for the United States." These publications are part of the DGE's State Resource Assessment program. These maps are designed to communicate to a user the relationship of natural thermal features, thermal wells, and areas considered to have a high probability of encountering additional geothermal resources to cultural features and land-use categories, such as parks, wilderness areas, national forests, Native American lands, and Department of Defense reservations.

State geothermal resource maps of Washington, Montana, North Dakota, Texas, Oregon, Arizona, Nevada, Wyoming, Virginia, Nebraska, Alaska, Kansas, Oklahoma, and Hawaii will follow in the future.

If you wish to obtain these products, send your name or card, your affiliation, and your address to: NOAA/NGSDC, Data Mapping Group, Code D64, Boulder, CO 80503.

Vincent C. Kelley and Leon T. Silver Graduate Fellowships

THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico invites applications for the Vincent C. Kelley and Leon T. Silver Graduate Fellowships. The fellowships will be awarded on the basis of the scholastic record and academic promise of graduate applicants. Each fellowship will provide for a generous living stipend of \$1,000/month for 9 to 12 months, and up to \$2,000/year for travel and research expenses. The Caswell Silver Foundation will pay all tuition and university fees. The awards are made on an annual basis, but may be renewed for up to three years as long as the student maintains excellent academic standing and shows evidence of significant progress in research. Preference will be given to, but is not restricted to, applicants for the Ph.D. program.

An application for admission to the UNM Graduate Program, transcripts, Graduate Record Exam results (verbal, math & geology), three letters of reference and a brief statement of research goals are required for consideration for the fellowships. Application materials may be obtained from:

Rodney C. Ewing
Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131



The deadline for applications is April 1, 1981 for the Fall semester of 1981.

The Caswell Silver Distinguished Professorship in Geology

THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico is pleased to invite nominations or applications for the Caswell Silver Distinguished Professorship in Geology. This endowed professorship shall be awarded for periods of up to two years to earth scientists of distinguished accomplishment and international reputation. The professorship may be held by scientists of all specialties of the earth sciences in the broadest sense, and the major criterion for selection is that the individual be an active, productive leader in his or her field of research. The recipient must carry out a vigorous research program while in residence at UNM. The recipient is expected to interact with the faculty and advanced topics of higher choice, during each academic year. The Foundation will provide unusually advantageous remuneration commensurate with the distinguished nature of the appointment. In addition, a liberal support, analytical services in department laboratories, use of field vehicles, and preparation of manuscripts will be provided.

Applications or nominations should include a detailed resume and brief statement of major research accomplishments. Applications or nominations should be forwarded to:

Rodney C. Ewing, Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131



The Caswell Silver Foundation is an equal opportunity employer.

Meetings

Gordon Research Conferences

Four of the Gordon Research Conferences scheduled for this summer will include discussions of interest to geophysicists. Emphasis at each conference is on the free exchange of ideas. One requirement of the conferences, for example, is that no information presented be used without the specific authorization of the individual making the contribution. The conferences, initiated by Neil E. Gordon 50 years ago, are self-supporting.

A session entitled "Environmental Sciences: Air," is scheduled for June 15-19 at the New Hampton School in New Hampton, New Hampshire. Jack G. Calvert will chair the conference.

Martin Watt will chair the conference on "Collisionless Shocks in Space, Astrophysical, and Laboratory Plasmas," scheduled for June 22-26 at the Brewster Academy in Wolfeboro, New Hampshire.

"Fluids in Permeable Media: Physics and Chemistry" will be the topic of the conference August 3-7 at the Tilton School in Tilton, New Hampshire. R. L. Reed and R. S. Schechter will preside.

Marco T. Einaudi and Hiroshi Ohmoto will cochair the session on inorganic geochemistry, slated for August 17-21 at Colby-Sawyer College in New London, New Hampshire.

Attendance at each conference is limited to about 100 conferees. Application forms, available from the director's office, must be submitted in duplicate. A registration card will be mailed to those selected. Advance registration is then required.

Applications and additional information can be obtained from Alexander M. Cruickshank, Director, Gordon Research Conferences, Pastore Chemical Laboratory, University of Rhode Island, Kingston, Rhode Island 02881.

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- Indexed by Author and Subject

Reserved copies of the EOS shelf edition will be shipped by March 15th.

To order EOS shelf edition, members may send \$10 to AGU, 2000 Florida Ave., N.W., Washington, D.C. 20009, others please inquire.

A limited supply of the '79 EOS shelf edition is still available.

The Fourth Conference on the Physics of the Jovian and Saturnian Magnetospheres

will be held at the

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The Johns Hopkins University

October 22 - 24, 1981

Voyager I and 2 and Pioneer II Results and
Theoretical Interpretation will be Emphasized

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- | | |
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| J. A. Van Allen | (University of Iowa) |

For further information, please contact:

S. M. KRIMIGIS
APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY
LAUREL, MARYLAND 20810

(301) 953-7100 X3252

in the data. There was no evidence in support of rapid (≤ 10 usec) plasma wave growth rates. Thus, the presence of large amplitude plasma waves generated immediately at the onset of the

Particles and Fields— Interplanetary Space

the liquid adjacent to the polyimide post-etch mask during the annealing process. The influence of the heating and cooling rate on the microstructure of the film is found to be applicable to the solar wind, in that as other stellar winds of any kind, in particular of whether or not these winds are associated with interaction with the solar wind, in short, there is short-wave distance, observed.

Phys. Zhen., Plus, Paper 140019

of two months of detailed examination of the data and simultaneous survey observations. (2) The observed windings of the meridional stream in the upper atmosphere to the very high geomagnetic latitudes and the simultaneous occurrence of the windings in the lower atmosphere in the equatorial area; and (3) the complete winding of the meridional stream in the upper atmosphere over several polar regions in the southern polar regions. The new features of the high-latitude windings in the

the largest nuclear power plants. Older generators data from 1959-1970 were used for the first 10 years of the study. Data from other years were also reviewed. It was found that the anomaly region had high activity of the propagation of the magnetic field. The results of the study are consistent with the hypothesis of the existence of a significant magnetic anomaly in the region of the magnetic meridian. The results of the study are consistent with the hypothesis of the existence of a significant magnetic anomaly in the region of the magnetic meridian. The results of the study are consistent with the hypothesis of the existence of a significant magnetic anomaly in the region of the magnetic meridian.

Particles and Fields—Magnetosphere

frequency in the electron equation of motion. When this term is combined with the continuity equation, the ion equation of motion and Maxwell's equations, a dispersion relation for the plasma gives rise to two modes of oscillation is found. The wave-particle interaction leads to a strong damping of the waves. Inclusion of the effects of plasma sheath kinetic yields a significant increase in the growth rate of the waves at frequencies near the upper hybrid frequency.

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